BIOLOGICAL TREATMENT OF

INDUSTRIAL WASTES*

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You are well aware of the interest and concern of the public in regard to its environment. Numerous studies, reports and publications are continually keeping us informed of the harm that may occur if pollution control is not practiced. The more highly industrialized a nation, the greater is its contribution to the disturbance of the ecosystem.

There are three general types of pollution: solid, liquid and gas. In any specific industry we may find "materials results from processing" that must be discharged as wastes either as smoke (gases and solids), liquids (containing solids) and gases or solids.

Before entering the discussion, let us define "wastes". Wastes are the unwanted products of man's ineptness or lack of creativity. They may be composed of those constituents that do not have a market value for a particular industry. This does not mean that they are not usable, further it does not mean that they are valueless. The wastes are effluents of man's productivity because they are byproducts. Before the invention of the internal combustion engine, gasoline was a waste

*Talk presented before the Delaware Valley Tanners' Club, November 8, 1973.

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product. The hide of an animal is a waste product to the meat packer but an asset to the tanner, shoe and machine belt manufacturer. The waste product of a mold, e.g. Penicillium notatum, may be an asset to the purveyor of antibiotics.

Liquid wastes from manufacturing processes contain soluble and suspended solids and dissolved gases which are discharged to the environment as an effluent. The nature of the composition of an effluent should be known by the producer. Its effect on the environment is known by the sanitary engineer and by the ecologist. Industrial effluents that contain high concentrations of putrescible compounds are discharged by tanneries, meat packers, distillers, wool processors, milk and cheese-processing plants and vegetable canners. Wastes that contain pernicious and noxious constituents are discharged by petroleum refineries, electroplating plants, natural gas plants, coal mines and paper manufacturers. Wastes that contain various concentrations of both organic and mineral impurities are: textile wastes, laundry wastes, tannery wastes and paper-mill wastes. According to Ruchhoft (1) and Straub (2), the production of radioactive effluents in considerable volumes arises from nuclear reactors, atomic energy stations, medical, industrial and research institutions.

Since World War II the development of nuclear fission processes has resulted in the production of large volumes of highly radioactive wastewaters. The safe and convenient disposal of these wastes without danger to aquatic life and public health has become more difficult as the progress of atomic energy synthesis advances.

The operator of a municipal waste treatment plant should know the composition of his influent when there are a number of industries discharging simultaneously into a combined sewer. The failure of an activated sludge process under these conditions cannot be blamed on any particular industrial waste when the concentrations and chemical properties of the combined wastes have not been determined before pumping into the mixed liquor tanks or on a trickling filter.

The nature or composition of an industrial waste depends on the manufacturing processes that are used. For example, the unit processes: dyeing, flushing, pickling, cooling, extracting and heating contribute large volumes of effluents with a wide variance in the concentrations of dissolved constituents. These range from small discharges containing concentrated, noxious compounds that are on the borderline of forming flocs or gels to very large discharge volumes containing only heat as a contaminant. (See Table).

APPROXIMATE QUANTITIES AND CONCENTRATIONS OF INDUSTRIAL WASTE WATERS*

Waste Water	Production Unit	Gals./Unit	Suspended Solids	BOD
Brewery	1 lb. beer	300-1000	250-650	500-1200
Cannery	1 ton stock	2500-8000	200-3000	300-4000
Milk Plant	1000 lb. milk	100-225		300-2000
Packinghouse, small	1 hog	1000-1500	500-1400	600-2000
Tannery	100 lb. hides	600-700	1000-5000	500-5000
Wool-scouring batch	100 lbs. wool	160-500	1000-170,000	200-10,000

*Fair, G. H., Geyer, J. C., Morris, J. C., Water Supply and Waste Water Disposal, John Wiley & Sons, Inc., New York, p. 867, 1959.

The quantity and strength of waste waters from a given industry vary within wide limits depending on the manufacturing processes employed. The strength of a waste is measured in terms of its BOD. The population equivalent of the BOD of industrial waste waters is the ratio of their BOD to the per capita BOD normally exerted by domestic or combined sewage (0.119 lb. per capita daily for domestic sewage and 0.165 lb. per capita daily per combined sewage, in 5 days at 20°C.). For example, the population equivalent of 0.5 million gallons per day (mgd) of a vegetable canning plant containing 4000 mg/L BOD is 4000 X 8.34 X 0.5/0.119 = 140,168 people in terms of domestic sewage and 140,168 X 0.119/0.165 = 101,090 people in terms of combined sewage. The population equivalent of a 0.5 mgd tannery waste containing 5000 mg/L BOD is 5000 X 8.34 X 0.50.119 = 175,210 people in terms of domestic sewage and 175,210 X 0.119/0.165 = 126,151 people in terms of combined sewage. The population equivalent of 20,000 gals./day from the hair pulping process is 0.02 mgd X 8.34 X 20,000/0.119 = 28,033 people in terms of domestic sewage and 28,033 X 0.119/0.165 = 20,218 people in terms of combined sewage. These figures are very important, especially in the case of a tannery situated in a town of 80,000 people where it discharges a loading to the sewage plant more than doubles that of the population.

If you do not intend to treat your wastes, you are going to be required to pay the costs to a municipality if it is able to accept your waste loading. The cost of treating an industrial waste is based on its BOD and suspended solids content. Some municipalities add a surcharge based on the size of the water meter and/or the discharge to the sewers.

Example 1:

A tannery typically discharges 8500 lbs. BOD/day from processing 2500 hides/day. The population equivalent for this industrial discharge is 8500 lbs./0.119 lbs./person = 71,429 people based on a domestic waste or 51,429 people in terms of combined sewage.

A town of 35,000 population agrees to treat the waste of this tannery at a rate of $0.115/lb. BOD in excess of 300 mg/L. Based on a 261 day-year, the tannery would pay $25,513. Although this is quite a substantial sum for a small town to collect, a gross error has been committed. Sewage plants are usually designed for expected population doubling in 20 to 30 years, but by accepting this tannery discharge they are now operating at full capacity with no capacity left for accepting any more wastes from possible industrial expansion.

Example 2:

A town of 50,000 people agrees to accept only the unhairing waste of a tannery. The BOD is 20,000 mg/L and the discharge is 20,000 gal./day, that is, 3336 lbs. BOD/day. The charge by the city is $10,012/yr. However, this town is in the same predicament as the former because this waste has a population equivalent of 28,033 people, greater than one half of the total population of the town. Again there is no capacity left for industrial expansion.

Example 3:

A town of 100,000 people desires to receive the revenue from a tannery that discharges 500,000 gal./day of waste at 5000 mg/L BOD. The population equivalent for this waste is equal to 175,000 people and the revenue charge is $62,379/yr. This town cannot handle the tannery waste because its sewage plant would be overloaded. The tannery operator must either partially or totally treat his effluent. Let us examine a few concepts that will enable the tannery to help solve these waste problems.

There are many waste treatment processes, i.e., chemical, aerobic, anaerobic, physical, auto-oxidation, trickling filter, primary, etc. The aerobic process has many modifications, such as conventional activated sludge, modified activated sludge, oxidation ditch and disc and step aeration. However, the first concern is to determine how best to treat the waste by available methods. Most wastes are studied first by using standard procedures, such as BOD, COD and suspended solids. This allows comparisons of information with chemists and engineers in other laboratories.

The first step is to perform a literature search to see what others have accomplished. This step will save thousands of dollars in research time. If the decision is to use activated sludge, then the treatability of the waste must be determined. The recommended procedure is to choose a bench-scale pilot plant of the fill and draw type, or the continuously fed pilot plant. In this type test the researcher must be able to vary the aeration times and the sludge holding times. Since activated sludge is in reality a bio-mass of many types of organisms, the nutritional requirements should be established. Ammonium and phosphate salts are basic requirements for most activated sludges to maintain a BOD to nitrogen ratio of 30 to 1 and a BOD to phosphate ratio of 40 to 1, depending on the conditions of acidity or alkalinity. Once the activated sludge unit has been set in operation the only requirement is to feed it and keep it aerated.

Next, examine the industrial waste. Is it oxidizable? By measuring the chemical oxygen demand (COD) and the five day biochemical oxygen demand (BOD) and taking their ratio, the extent of degradation which can be expected by activated sludge is indicated. A ratio greater than BOD/COD = 0.6 indicates that the industrial waste is oxidizable. A ratio = 0.0 indicates that it is toxic and not treatable. A ratio between 0.1-0.4 means that no degradable substances are present. If the pH is too far from the neutral range, it must be adjusted by adding an acid or base. Tannery unhairing wastes have a high pH and contain sulfide ion, protein and fats. Acclimatization of the activated sludge will have to be done first in order to measure the treatability of the unhairing waste.

In conclusion the question is often asked by the manufacturer, "What information do I need to know and who do I hire to handle my waste problems?" The answer is simple. First the tanner knows his process (the raw materials, the products and the by-products), this is the necessary condition to stay in business. However, a lack of knowledge of the waste products may put him at odds with the law. Therefore, it is necessary for him to know the major components of his effluents which are to be discharged as wastes. Second, the tanner must hire the expertise to research the problem. The municipality must do the same. The problem: Are my wastes able to be treated by a process so that they will no longer pollute streams and air? If they are not treatable by biological methods why not recover the major components for reuse in the process stream?

This brief discussion will give some insight into the rationale and experimental approaches in the biochemical aspects of industrial waste treatment. A great amount of work has been done in this field, but more remains to be accomplished. This area of research is especially interesting and valuable at this time because of the current emphasis on cleaning up the environment. Much of what applies to tannery wastes may also in the long run apply to meat packing wastes and other allied industries.

References

1. Ruchhoft, C. E. and Setter, L. R. Application of Biological Methods in the Treatment of Radioactive Wastes, Sew. & Ind. Wastes, 25, No. 1 (1953).

2. Straub, Conrad P., Observations on the Removal of Radioactive Materials from Waste Solutions, Sew. & Ind. Wastes, 23, No. 2 (1951).